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The Defense Mapping Agency Aerospace Center has developed a program to exploit digital image technology for the advancement of mapping, charting, and geodesy. Primary investigations include image processing, analysis, and display techniques, and computer image generation. A dramatic impact has been made in the ability to produce, analyze, and validate digital data bases produced by the Defense Mapping Agency by applying state-of-the-art digital image technology concepts to the development of new interactive prototype and production cartographic systems.

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DIGITAL IMAGE TECHNOLOGY: Cartographic Systems

at the Defense Mapping Agency Aerospace Center

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ABSTRACT

The Defense Mapping Agency Aerospace Center has developed a program to exploit digital image technology for the advancement of mapping, charting, and geodesy. Primary investigations include image processing, analysis, and display techniques, and computer image generation. A dramatic impact has been made in the ability to produce, analyze, and validate various digital data bases produced by the Defense Mapping Agency by applying state-of-the-art digital image technology conce[illegible] to the development of new interactive prototype and production cartographic systems

INTRODUCTION

With the introduction of digital image technology into the scientific community, the Defense Mapping Agency (DMA) began a program to exploit this technology for the advancement of mapping, charting, and geodesy (MC&G). Primary areas of in-house application engineering are image proc sing, image analysis for automated feature extraction, image display techniques for data base analysis, and computer image generation/sensor simulation for advanced weapon systems support (Faintich, 1979). Specialized digital image technology hardware for cartographic production systems is continuing to be developed and procured as a result of investigations using the major developmental hardware at DMA during the 1974-1980 time frame, the OPTRONICS Scanning, Digitizing, and Reimaging (SDR) System (see Figure 1).

IMAGE PROCESSING

To support both image analysis and electro-optical correlation systems, DMA has developed a general purpose digital image processing software package to accomplish image restoration, enhancement, noise removal and geometrical warping. Spatial convolution filters, pixel histogram manipulations, transform coding and filtering, and compression techniques are included. In order to allow for extensive in-house digital testing with digital stereo displays and interactive image scanning, DMA is installing Remote Work Processing Facilities (RWPF) in the production centers during 1980-1981 (see Figure 2). The RWPF will be augmented with the DMA image processing software

package and new algorithms as they are developed. After installation, the major portions of pilot MC&G digital operations, digital photo interpretation and feature extraction, and general digital image technology experimentation will be conducted on the RWPF. Future plans for the RWPF include linkage of the systems to major image processing installations.

IMAGE ANALYSIS FOR AUTOMATED FEATURE EXTRACTION

Some of the major programs at the DMA are the production of the Digital Landmass System (DLMS) and other digital data bases that describe the physical appearance of the surface of the earth. These data bases include, but are not limited to, terrain elevation, culture including landscape characteristics, and vertical features. A major problem in the production of these digital data bases is the extreme cost of primarily manual photo interpretation of surface features. Various digital techniques are being investigated to develop a digital image analysis capability for feature extraction. The developments are addressing automated classification from both multi-spectral and conventional black and white imagery.

Initial goals were addressed by the procurement in 1979 of a Digital Interactive Multi-Image Analysis System (DIMIAS) which primarily exploits LANDSAT Multi-Spectral Scanner (MSS) data (see Figures 3 and 4). Investigations demonstrated that LANDSAT multi-spectral data can be used to meet current production standards for landscape feature extraction, with a significant increase in the throughput rate. The current manhour savings is 15 percent of the feature analysis time for areas processed on the

DIMIAS. Essential aspects of this system, which provided an initial production capability in March 1980, are its automated processing capability and interaction with the feature analyst for on-line digital image manipulation.

The next planned improvement in feature analysis collection will be accomplished through the Computer Assisted Photo Interpretation (CAPI) system. CAPI is an integrated photo interpretation/digital compilation work station incorporating interactive analytical stereophotogrammetric mensuration, data entry and validation, digitization, and editing, based upon polarized real image stereo display technology under microprocessor control. (See Figure 7.) Source photography for CAPI will be unrectified images. The analyst will have the capability to classify all DLMS feature types with this system (surface material categories 1-13); however, it will primarily be utilized for the extraction of non-landscape type features. Landscape features extracted by DIMIAS will be merged with CAPI output.

Additional in-house techniques development and procurement efforts have been pursued as near-term enhancements of present production procedures. These include feature analysis data table (FADT) entry and verification, absolute positioning, manuscript digitizing equipment, and feature measuring techniques. Three hardware/software systems have been considered to automate the FADT generation which comprises about 15% of the total feature analysis effort. They are the OpScan 17 optical character reader, Interactive Feature Analysis Support System (IFASS), and voice entry technology. Under present procedures, absolute positioning of extracted features is accomplished through the use of line graphics, USGS quad maps, and orthophoto bases. Development of the *Continental Control Network* (CCN) and the procurement of an Off-Line Ortho-Photo System (OLOPS) has expanded our ability to obtain control information throughout the DLMS program area in graphic or numerical form. Another significant new system is the Automated Graphic Digitizing System (AGDS, Figure 8). AGDS is programmed to support

digitization in feature analysis production and in automated cartography. The three independent AGDS scanning, vectorization and editing subsystems provide a significant increase in digitizing capability.

The primary R&D system of the FY81-85 time period is an interactive, semi-automated feature analysis system for the expanded DLMS and other feature types. Previous R&D programs contained several projects that addressed certain types of feature analysis algorithms. These projects, however, did not address the total algorithm development requirement. In order to form the basis for the FY85 interactive system production implementation, new feature extraction algorithm studies were started in the FY79-81 period that addressed state-of-the-art analysis of hybrid feature extraction techniques that were not covered by specialized R&D studies. In addition, other studies were enhanced by new algorithm development including advanced pattern recognition, spatial pattern recognition, sensorgrammetric mapping, image understanding, and advanced feature analysis algorithm development. In the interim, some of the techniques evaluated for the system may be utilized in improving or designing advanced versions of CAPI and DIMIAS, with possible application to aeronautical as well as DLMS feature analysis.

The goal of the FY85-90 time frame is to phase into a fully or nearly total automated feature analysis system with only manual validation check points. The FY90 automated feature analysis system is to be an integral part of the DMA production scenario. The overall concept for DMA automation is addressed by the R&D project "System '90". The basic concept of "System '90" is to phase DMA into an increased production posture with reduced cost by exploiting emerging digital technologies. Implementation of "System '90" will be achieved by the integration of R&D programs, in-house testing, and extensive concept/system design analysis. The Pilot Digital Operations will play a significant role

in helping to achieve the "System '90" goal. In addition, the DMA Centers' Remote Work Processing Facilities will serve as the test beds for digital operations.

IMAGE DISPLAYS FOR DATA BASE ANALYSIS

The digital terrain elevation data produced by the Defense Mapping Agency supports a wide variety of products, including input to electro-optical sensor simulators, guidance systems, and automated cartographic systems. This data is collected from source maps using the Lineal Input System and the AGDS, and from stereo-pairs of photographic imagery using optical correlation processes. In order to facilitate the display of these data bases for analysis, techniques for various types of display have been developed.

Along classical MC&G lines, a digital terrain elevation matrix may be used to generate a standard contour plot and the corresponding tint plate. For advanced analysis, terrain data may be depicted in the form of gray level elevation code or shaded relief from various sun angles. In addition, photogrammetric models may be applied with shaded relief techniques to generate pseudo-stereo-pairs from the data bases. Additional information is gained from applying digital image convolution techniques to the digital terrain elevation data. Convolution techniques allow for one meter level analysis of the digital elevation data.

These advanced techniques have been incorporated into production quality control units called Image Manipulation Stations (IMS, Figure 7). The IMS units will be eventually

integrated into the Digital Data Base Analysis Sytem (DBAS), a system being developed to manage the DMA digital cartographic data bases.

In order to support DLMS terrain and culture processing functions, the Interactive Processing and Analysis System (IPAS) will be procured. IPAS will be designed to interactively convert digitized contour lines to digital terrain matrix data, to generate contour information from digital terrain matrices, and to edit DLMS terrain and culture processing anomalies. The IPAS will employ multiple interactive color image display work stations interfaced with a central processing unit and peripherals.

Another new system to be procured is the Digital Chart Revision System (DCRS). The DCRS will utilize digital chart information from the AGDS for interactive chart edition/revision with output of new chart data to various plotter subsystems. Initially, it is expected that the interactive display system will be a graphics display system.

COMPUTER IMAGE GENERATION/SENSOR SIMULATION

The primary objective of the digital sensor simulation investigations being conducted at DMA is to establish an editing and analysis capability for the digital culture and terrain data bases. These data bases are being produced by DMA to support advanced aircraft simulators by providing an improved low level radar training capability offered by the digitally generated radar landmass images. As a result of the technology developed for the aircraft simulator support, sensor guidance reference scenes are also being generated.

In addition to radar scenes, visual and multi-sensor scenes are being digitally generated. For purposes of quality control and data base applicability investigations, the DMA has developed the Sensor Image Simulator (SIS), a very high speed data base edit station and static scene simulator that allows for interactive query and manipulation of individual features in the data base displays and/or simulated sensor scenes to determine the corresponding data base elements responsible for the simulated features (see Figure 9). The SIS was installed at DMA in 1981 and plays a key role in determining the applicability of prototype data bases for use in advanced training simulators, as well as insures the quality of and coherence between the various digital data bases prior to new data insertion into the master cartographic data base files (Figure 10).

CONCLUSIONS

The development of digital image technology has made a dramatic impact upon classical production methodologies for mapping, charting, and geodesy. DMA has begun to develop a new line of digital products to support advanced aerospace weapons systems, and new cartographic systems based upon digital image technology are playing a key role in the production, analysis, and validation of these products.

REFERENCE

Faintich, M. B; 1979; "Digital Image Technology: MC&G Impact," Harvard Library of Computer Graphics/1980 Mapping Collection, Volume 10, pp. 29-40; reprinted in condensed form in the Proceedings of the American Society of Photogrammetry, Annual Convention, St. Louis, Missouri, 9-14 March 1980, pp. 32-43.

LIST OF CAPTIONS

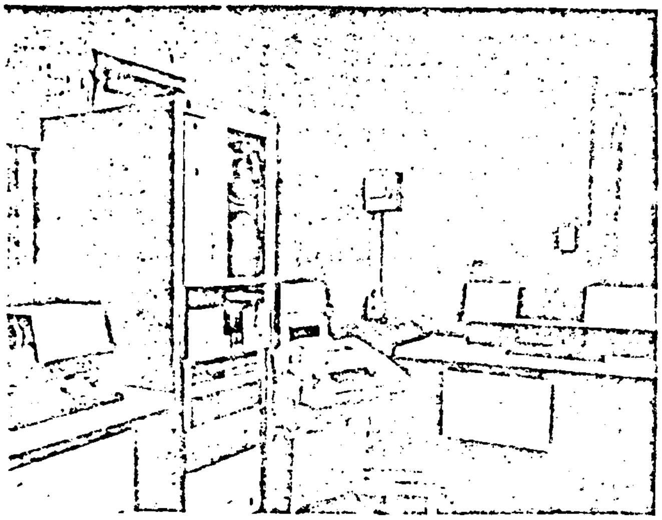


Figure 1. OPTRONICS Scanning, Digitizing, and Reimaging System

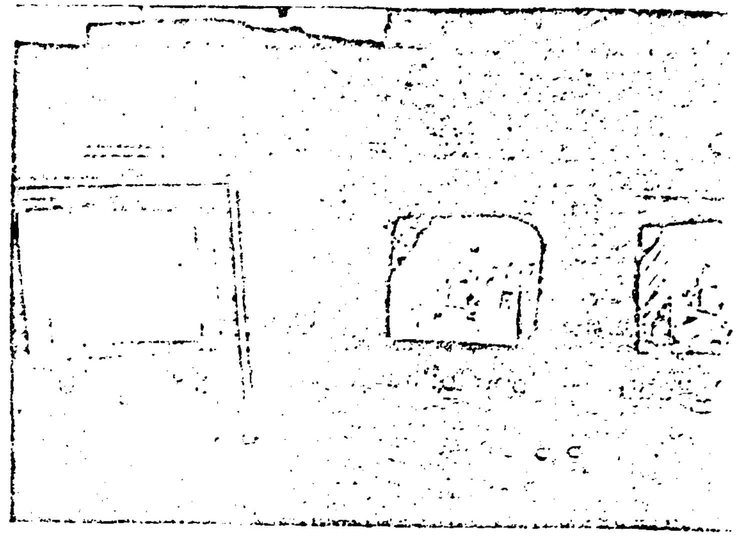


Figure 2. Remote Work Processing Facility Work Station

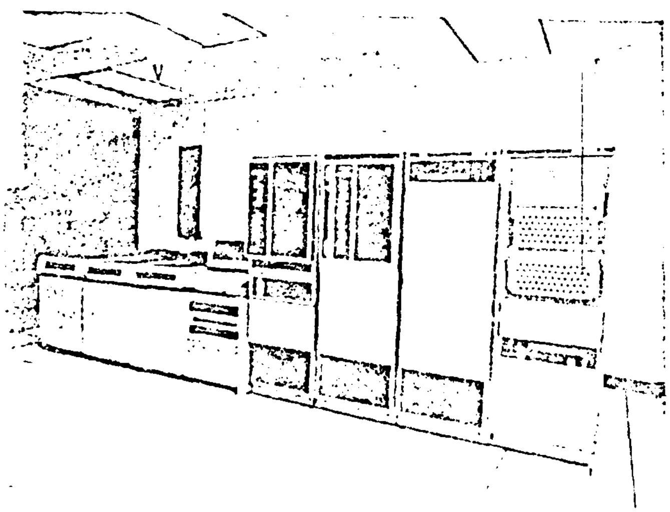


Figure 3. DIMIAS Computer Bank

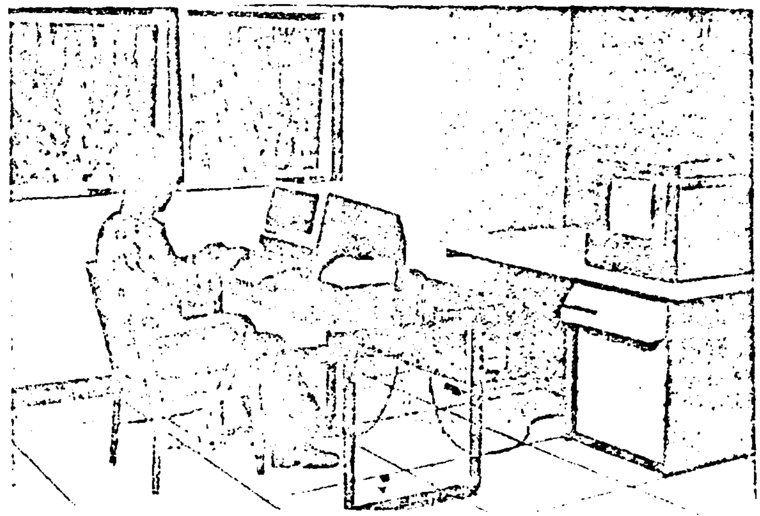


Figure 4. DIMIAS Work Station

Figure 5. LANDSAT Image

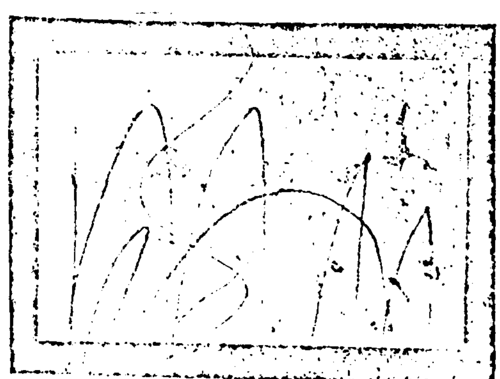


Figure 6. Extracted Landscape Features

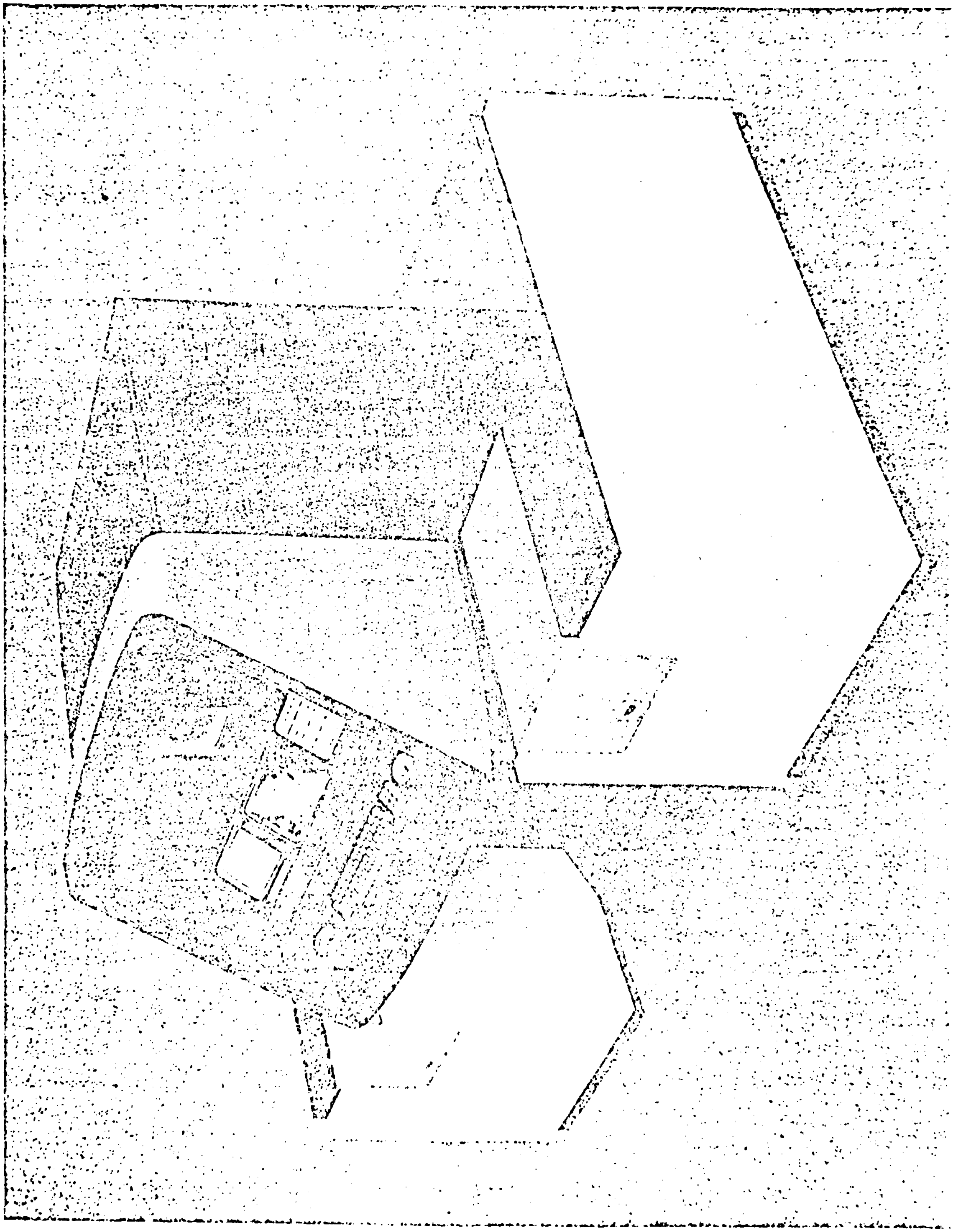
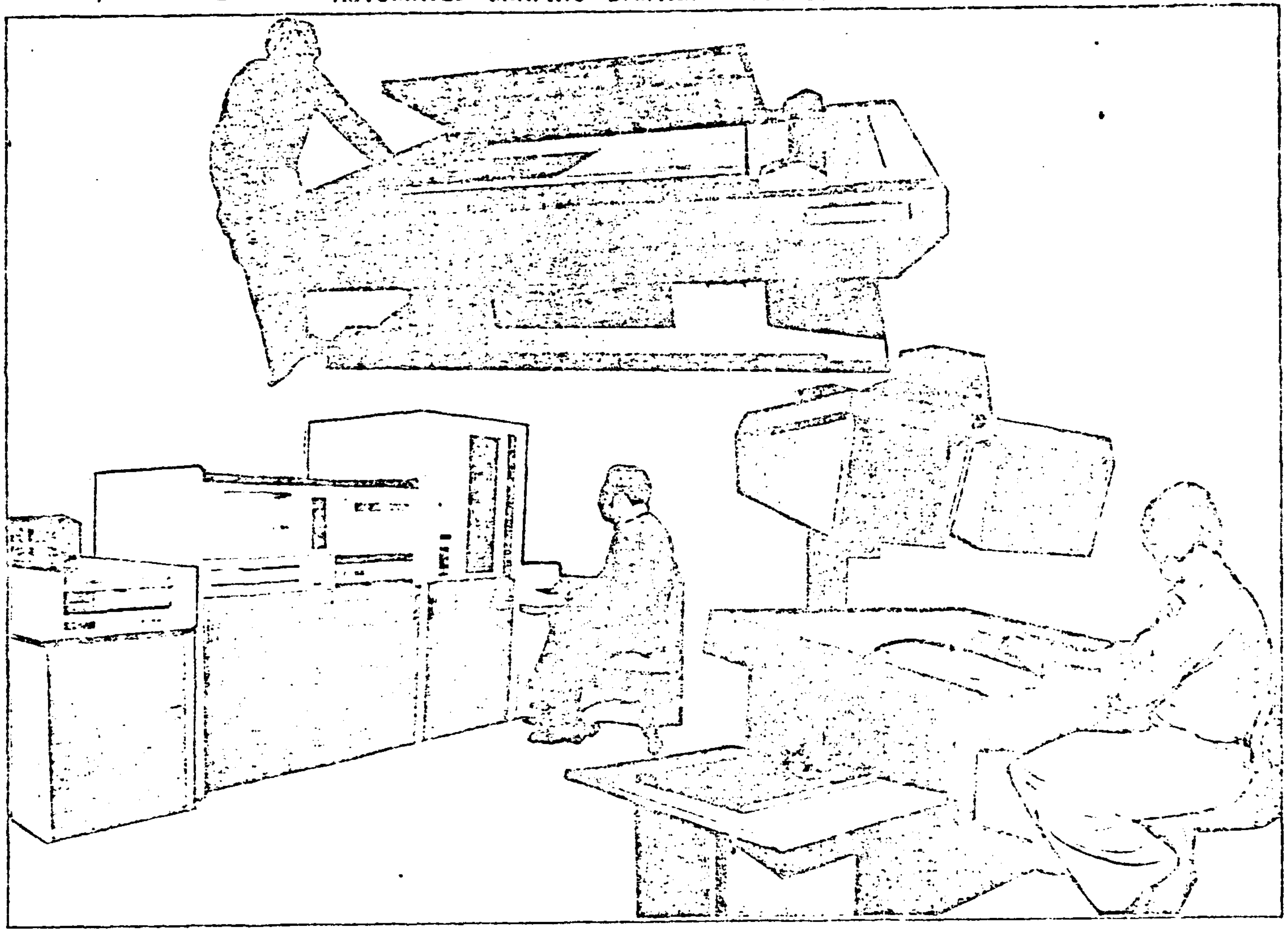


Figure 3~~-1~~. ~~Artist's Concept of the TRASTER CAPI SST System~~

5 Computer Assisted Photo Interpretation (CAPI) System

FIG. 6 AUTOMATED GRAPHIC DIGITIZING SYSTEM (AGDS)



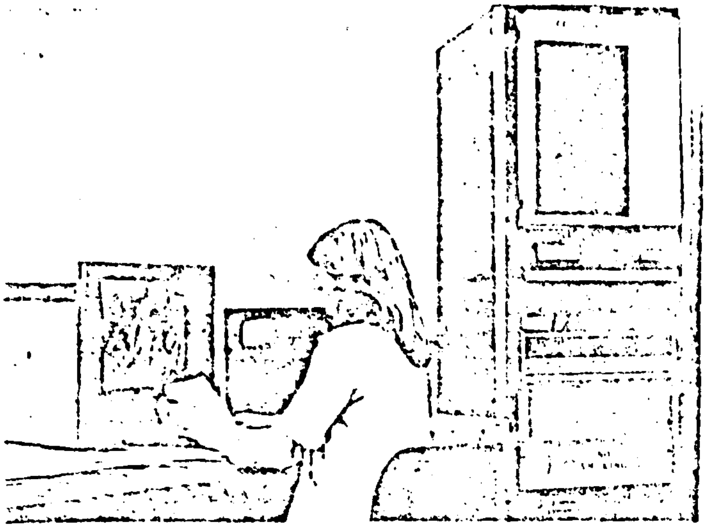


Figure 7. Image Manipulation Station

Figure 8. Convolved Terrain Elevation Matrix

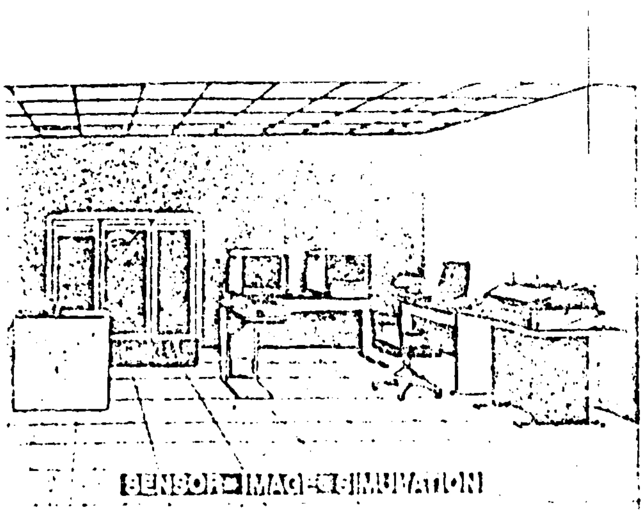


Figure 9. Sensor Image Simulator System

Figure ~~10~~ 9. Sensor Image Simulator Work Station

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